Near-Infrared persistent luminescence: the quest for traps

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Persistent luminescent materials or glow-in-the-dark compounds have been studied and developed since a long time, and are finding more and more applications in everyday life. They are used in emergency lighting, toys and clothing, experiments are performed to introduce them in self-lit road signs, and a few years back, a glow-in-the-dark electric car Nissan Leaf was presented. All these uses are based on visible light emission, but for some applications, near-infrared emission is required. Notably, a pioneering article in 2007 demonstrated the proof of principle of in vivo medical imaging of small animals using the near-infrared emission of a persistent phosphor [1].

Most persistent phosphors use Eu^{2+} as the emitting center, but other dopants are much more suited for long-wavelength persistent luminescence. The present work focusses on both Cr^{3+} [2,3] and Mn^{4+} [4], with an emission wavelength around 700 nm. The former dopant was incorporated in the spinel $LiGa_5O_8$, while the latter was substituted in the perovskite host $LaAlO_3$. Since both ions have an identical electron configuration, their optical characteristics are also very similar, but their specifics will be discussed in detail in this presentation.

Next to the synthesis methods for the single-phase compounds, their excitation and emission characteristics, attention will be given to the way the dopants are incorporated in the host lattice, how this influences the trap levels, needed to obtain persistent luminescence, and how these trap levels can be influenced by co-doping. Dopant incorporation and oxidation state was studied using x-ray absorption spectroscopy, complemented with electron paramagnetic resonance measurements. Trap levels and their relation to the afterglow characteristics were studied using thermoluminescence experiments with different charging temperatures and fading times.

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